CERTIFICATE OF VERIFICATION

I, So Yeon, KIM of 648-23 Yeoksam-dong, Gangnam-gu, Seoul, Republic of Korea state that the attached document is a true and complete translation to the best of my knowledge of the Japanese-English language and that the writings contained in the following pages are correct English translation of the specification and claims of the Korean Patent Application No. 10-2000-11325.

Dated this 24th day of November 2004.

Signature of translator: Soyeon Kim

So Yeon, KIM

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(54) Multidomain Liquid Crystal Display Device

ABSTRACT

Disclosed is multidomain liquid crystal display including a first substrate and a second substrate, a liquid crystal layer between the first and second substrates, a plurality of gatelines and datalines on the first substrate crossed each other at fixed intervals, for defining pixel regions, at least one field induction window in each of the pixel regions, and a photo-alignment film, in a pretilt angle, formed at least one of the first and second substrates.

TYPICAL DRAWING

FIG. 1a

INDEX WORDS

Multidomain, Field induction window, photo-alignment

[SPECIFICATION]

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIGS. 1a, 1b and 1c illustrate a section of a multi-domain liquid crystal display in accordance with a first, second and third preferred embodiments of the present invention;

FIGS. 2a, 2b, 2c, 2d and 2e illustrate a plan view of varied examples of a multi-domain liquid crystal display in accordance with a fourth preferred embodiment of the present invention;

FIGS. 3a, 3b, 3c and 3d illustrate a plan view of varied examples of a multi-domain liquid crystal display in accordance with a fifth preferred embodiment of the present invention;

FIGS. 4a, 4b, 4c and 4d illustrate a plan view of varied examples of a multi-domain liquid crystal display in accordance with a sixth preferred embodiment of the present invention;

FIGS. 5a and 5b illustrate a plan view of varied examples of a multi-domain liquid crystal display in accordance with a seventh preferred embodiment of the present invention;

FIG. 6 illustrates a plan view of a multi-domain liquid crystal display in accordance with an eighth preferred embodiment of the present invention; and

FIGS. 7a and 7b illustrate characteristics of viewing angle of a multi-domain liquid crystal display in accordance with the preferred embodiment of the present invention and related art, respectively.

Reference numerals of the essential parts in the drawings

1: gate bus lines	3: data bus lines
5: semiconductor layer	6: source electrode

9: drain electrode 11: gate electrode

13: pixel electrode 17: common electrode

23: color filter layer 25: light-shielding layer

29: uniaxial phase difference film 31: first substrate

39: contact hole 43: storage electrode

47: liquid crystal 51: electric field induction window

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND DISCUSSION OF THE RELATED ART]

The present invention relates to a liquid crystal display device (hereinafter, referred to as LCD), and relates more particularly to a multidomain LCD having a simplified manufacturing process, an improved viewing angle and increased transmissivity.

A LCD generally uses a twisted nematic (hereinafter, referred to as TN)-LCD mode as a large-sized and high-quality liquid crystal display device, in which a liquid crystal alignment film is arranged in an inner side of a transparent electrode directly adjoining with the liquid crystal molecule. In the boundary between the liquid crystal alignment film and the liquid crystal molecule, the liquid crystal molecule could be either arranged unaxially by an unaxial drawing or be inclined having a pretilt angle with the liquid crystal alignment film.

As a method of the unaxial drawing, in general, a rubbing method is widely used in the industrial field owing to its simple and fast procedure of making large the size of the display device by rubbing a substrate on which is coated with high polymer, with an alignment clothing.

Also, if the substrate is rubbed by the above method, micro grooves are formed

on the alignment film. These micro grooves are arranged in parallel with liquid crystal molecules so as to minimize the elastic deformation energy. However, since the shape of the micro grooves is varied upon the rubbing strength between the alignment clothing and the alignment film, the liquid crystal molecules are arranged in irregularity, which may subsequently cause a phase distortion or a light scattering and thus posing a considerable effect on a performance of LCD.

Therefore, it is required a sufficient consideration in practicing the rubbing method since is delicately changed in accordance with a value of the pretilt angle, coating condition and rubbing condition. Also, minute dust or an electrostatic discharge (ESD) may generated due to the static electricity during the rubbing of the high polymer coated substrate with the clothing. The dust is a major obstacle in manufacturing Thin Film Transistor (TFT) the process of which is a repetition of four steps of depositing pixel electrode, coating, exposition and etching. A partial discharge may damage the alignment film itself or may cause a disconnection of transparent electrodes or TFT, or destroy the static electricity. Moreover, the alignment film for TFT should have a characteristic of storing voltage so as to maintain charged electricity therein for a long time.

In particular, the TFT-LCD has different refractive anisotropy between the light propagating in a direction of the longitudinal axes of liquid crystal molecules and the light propagating in a direction perpendicular to the direction of the longitudinal axes, in that an optical transmissivity in perpendicular direction is formed in a symmetrical manner, while formed in asymmetrical way to longitudinal direction. Therefore, an image may be reverse within a certain range, in the longitudinal direction, which results in a viewing angle that is substantially narrow.

To cope with the refractive anisotropy a multidomain TN-LCD, such as Two

Domain TN(TDTN)-LCD, Domain Divided TN(DDTN)-LCD, are suggested. These multidomain TN-LCD are fabricated generally by two methods of photolithography and rubbing. In other words, to form a domain having different alignment directions to one another, the above photolithography and rubbing process should be performed in two times. Through the above process, the TN-LCD having 4 domains could be made.

However, the 2-domain TN-LCD having the contrast ratio more than 10 has the longitudinal viewing angle of only ± 25°C and the 4-domain TN-LCD has the viewing angle of ± 40°C. Also, not only the manufacturing process is very complicated, but also a tilt angle of the same is also unsafe and a reliability of a liquid cell is also lowered.

To solve the problems caused by the rubbing, a photo-alignment method is suggested, which irradiates ultra violet rays for two times to determine the alignment direction.

However, the above photo-alignment method has some disadvantages of weakened anisotropy to photo-alignment film, anchoring energy, disclination due to the alignment irregularity of liquid crystal and a trace of a flow of a liquid occurred during an insertion of the same. Also, the above method requires irradiating four times to form one domain, which will make the irradiating process very complicated.

[TECHNICAL TASKS TO BE ACHIEVED BY THE INVENTION]

Accordingly, the present invention is directed to a multi-domain liquid crystal display device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a multi-domain liquid crystal display device in which a photo alignment film having a pretilt is formed at least one of an upper and lower substrates and the other substrate has an electrical field induction window patterns thereon, so as to perform a multidomain effect.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a multi-domain liquid crystal display device according to the present invention includes: a first substrate and a second substrate, a liquid crystal layer between the first and second substrates, a plurality of gatelines and datalines on the first substrate crossed each other at fixed intervals, for defining pixel regions, at least one field induction window in each of the pixel regions, and a photo-alignment film, in a pretilt angle, formed at least one of the first and second substrates.

In another aspect of the present invention, the multidomain liquid crystal display device further includes a gate insulation film, protective film and pixel electrode formed on the first substrate, in a pattern.

In another aspect of the present invention, the pixel electrode is divided into two regions, each of which includes liquid crystal molecules having different movements from each other, and the photo alignment film is divided at least in two regions, each of which includes liquid crystal molecules having different alignment characteristics from each other.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A multi-domain liquid crystal display device of the present invention will be described with reference to the accompanying drawings.

FIGS. 1a, 1b and 1c illustrate a section of a multi-domain liquid crystal display in accordance with a first, second and third preferred embodiments of the present invention, and FIGS. 2a, 2b, 2c, 2d, 2e, 3a, 3b, 3c, 3d, 4a, 4b, 4c, 4d, 5a and 5b illustrate a plan view of varied examples of a multi-domain liquid crystal display in accordance with a seventh preferred embodiment of the present invention.

As shown in the above FIGS., the multi-domain liquid crystal display device

according to the present invention includes a first substrate and a second substrate, a plurality of data lines 3 and gate lines 1 formed on the first substrate lengthwise and crosswise to divide the first substrate into a plurality of pixel regions, a gate electrode 11 formed in each pixel region on the first substrate, a gate insulating film, a semiconductor layer 5, an ohmic contact layer, a thin film transistor including a source/drain electrodes 7 and 9, a protective film is formed on an entire surface of the first substrate, and a pixel electrode 13 formed on the protective film forming an electrical field induction window 51 therein and being connected with the drain electrode 9.

And, on the second substrate, there is a light shielding layer 25 for shielding a light leaking from the gate lines 1, the data lines 3, and the thin film transistors, color filter layers 23 each formed in a region corresponding to each of the pixel regions between the light shielding layer 25, and a common electrode 17 each extended over the color filter layer 23 and the light shielding layer 25. And, there is a liquid crystal layer 40 formed between the first substrate and the second substrate.

To prevent the lowering of reliability due to a chemical action between color filter layers 23 and the liquid crystal layer, there could formed a protective film inserted therebetween, and in within the case, an overcoating layer may be formed on the color filter layer 23 before forming the common electrode 17 thereon.

A method for fabricating the aforementioned multi-domain liquid crystal display will be explained.

To fabricate the aforementioned multi-domain liquid crystal display device, the thin film transistor consisting of the gate electrode 11, the gate insulating film, the semiconductor layer 5, the ohmic contact layer and the source/drain electrodes 7 and 9, are formed in each pixel region of the first substrate. At this time, the plurality of gate

lines 1 and data lines 3 are formed to divide the first substrate into a plurality of pixel regions.

The gate electrode 11 and the gate lines 1 are formed of one or two layers of a metal, such as Al, Mo, Cr, Ta and Al alloy by sputtering and patterning. The gate insulating film is formed of SiNx or SiOx by PECVD (Plasma Enhancement Chemical Vapor Deposition) and patterning.

And, the semiconductor layer 5 and the ohmic contact layer are formed of a-Si and n^+ a-Si by PECVD and patterning. The gate insulating film and the a-Si and n^+ a-Si may be deposited by PECVD in succession to form a gate insulating film, and patterned to form the semiconductor layer and the ohmic contact layer. And, the data lines 3 and the source/drain electrodes 7 and 9 are formed of a metal, such as Al, Mo, Cr, Ta and Al alloy by sputtering and patterning.

Then, a protection film is formed of BCB (BenzoCycloButene), acrylic resin, polyimide compound, SiN_x or SiO_x on an entire surface of the first substrate, and ITO (Indium Tin Oxide), or a metal, such as Al or Cr, are sputtered thereon and patterned, to form a pixel electrode 13. In this instance, the pixel electrode 13 is connected to the source/drain electrodes 7 and 9 through a contact hole 39.

And, the pixel electrode 13 or the protection film may be patterned to form a field induction window 51 in a form of slit or hole, or the gate insulating film may be partially or totally patterned, to form the field induction window 51.

Then, a light shielding layer 25 is formed on the second substrate, and a color filter layer 23 is formed such that R, G, B (Red, Green, and Blue) elements are repeated in every pixels. And, alike the pixel electrode 13, a common electrode 17 of a transparent material, such as ITO, is formed on the color filter layer 23, and, after the first substrate and the second substrate are bonded together, liquid crystal is injected

between the first and second substrates, to complete fabrication of a multi-domain liquid crystal display. The liquid crystal is nematic with a negative or positive dielectric anisotropy, and may be added with a chiral dopant.

As shown in FIGS. 2, 3, 4 and 5, the electrical field induction windows 51 may be formed in different positions in implementation of the multi-domain effect. And, in the figures, arrow points indicate the alignment directions of the substrates. That is, by patterning width, length, and both diagonal directions, an effect of two divided domains is obtained, or by patterning forms of 'x', '+', double Y (refer to FIG. 4b), and '◊' and ' x', and '+' on the same time, effects of four divided domain and multi-domain can be implemented. Although not shown in the drawings, the field induction window could be also formed in the common electrode 17 on the second substrate.

Additionally, one coat of polymer is applied on at least one of the first or second substrates to form a phase difference film. The phase difference film, a negative uniaxial film, is formed of a uniaxial material having only one optical axis, for compensating users vision for a change of viewing angle with respect to a direction vertical to the substrate, that enlarges an area with no gray inversion, and increases a contrast ratio in an oblique direction, and left/right direction viewing angles can be compensated more effectively by forming on pixel in multi-domain.

In the multi-domain liquid crystal display of the present invention, other than the negative uniaxial film, the phase difference film may be a negative biaxial film, of a biaxial material with two optical axes, for obtaining a wider viewing angle than the uniaxial film.

After the phase difference film is formed, a polarizer is attached to both substrates. The polarizer may be applied as an integrated unit with the phase difference film.

FIG. 6 illustrates a plan view of a multi-domain liquid crystal display in accordance with an eighth preferred embodiment of the present invention.

As shown in FIG. 6, the multi-domain liquid crystal display of the present invention has an L-lined thin film transistor structure, which disposes a storage electrode 43 to be overlapped on the gate line 1 so as to form a storage capacitor and has an L-lined TFT on the gate line 1, that can increase an aperture and reduce a parasitic capacitance formed between the gate line 1 and the drain electrode 9.

And, the multi-domain liquid crystal display of the present invention has an orientation film (not shown) formed on an entire surface of the first and/or second substrate. The orientation film may be of an optical alignment film formed of a material selected from compounds of PVCN (polyvinylcinnamate), PSCN (polysiloxanecinnamate), or CelCN (cellulosecinnamate) group, but any material suitable for a photo-alignment can be applicable. The photo orientation film fixes a pretilt angle direction and an alignment direction or a pretilt angle of a director of a liquid crystal molecule on the same time by at least one time of light irradiation that permits to secure alignment stability of the liquid crystal. The light used for the optical orientation is a light of an UV range, and may be a non-polarized light, a linearly polarized light, or partially polarized light.

The pretilt angle is within 1°~5°, and more preferably from 2°~3°.

The photo-alignment may be applicable to one or both of the substrates, and the alignment processing may differ for the two substrates, or the alignment processing may not be applied while the alignment film is formed.

The alignment processing permits to form a multi-domain liquid crystal display with at least two domains in which alignments of the liquid crystal molecules in the liquid crystal layer differ from each other. That is, one pixel is divided into four regions

in a form of '+' or 'x', or in a length and a width directions, or in diagonal directions, and an alignment processing or an alignment direction in each of the regions or in each of the substrate is made differently, for implementing a multi-domain effect. At least one of the divided regions may be left unaligned, and it is possible to leave all the regions unaligned.

FIG. 1 illustrates a sectional view of a multi-domain liquid crystal display device having regions oriented, FIG. 1a illustrates an embodiment of forming pretilt by optical-orienting the alignment film of the first substrate, FIG. 1b illustrates an embodiment of forming pretilt by optical-orienting the alignment film of the second substrate, FIG. 1c illustrates an embodiment of photo-orienting the first and second substrate, for implementing the multi-domain effect, in more effective way.

FIGS. 7a and 7b illustrate characteristics of viewing angle of a multi-domain liquid crystal display in accordance with the preferred embodiment of the present invention and related art, respectively.

Referring to FIG. 7a, a contrast ratio of a conventional mono-domain liquid crystal display device is formed in an oblique direction, which makes it difficult to form a regular viewing angle, but as shown in FIG. 7b, the liquid crystal display device with two domains is symmetrical in perpendicular direction in a wide range, and thus may provide with a regular viewing angle from all directions, thereby making it possible to fabricate a high-quality liquid crystal display device in a simple manufacturing process.

Also, the multi-domain liquid crystal display device in accordance with the present invention could be applied in various forms of alignment, such as the axis of the liquid molecule could be in a homogeneous alignment which is arranged in parallel to the first and second substrates, in a tilted alignment which is formed having a certain angle to the first and second substrates, in a twisted alignment which is twisted, and in a

hybrid alignment in which any of the first and the second substrates are aligned longitudinally while the other perpendicular thereto.

[EFFECT OF THE INVENTION]

As has been explained, the multi-domain liquid crystal display of the present invention has the following advantages.

First, the optical orientation of at least one of the substrate and the formation of field induction window in the lower substrate may render simplify a fabrication process, and maximize a multi-domain effect.

Second, the pretilt and anchoring energy obtained by the photo-alignment may provide with a quick response time and a safe liquid crystal structure.

It will be apparent to those skilled in the art that various modifications and variations can be made in the multi-domain liquid crystal display of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents

What Is Claimed Is:

1. A multi-domain liquid crystal display device according to the present invention comprises:

a first substrate and a second substrate;

a liquid crystal layer between the first and second substrates;

a plurality of gatelines and datalines on the first substrate crossed each other at fixed intervals, for defining pixel regions;

at least one field induction window in each of the pixel regions; and

a photo-alignment film, in a pretilt angle, formed at least one of the first and second substrates.

2. The device as claimed in claim 1, wherein the pretilt angle may be within $1°\sim5°$.

3. The device as claimed in claim 1, wherein the plurality of gatelines and datalines on the first substrate crossed each other to form an L-lined thin film transistor.

4. The device as claimed in claim 1, wherein the first substrate disposes a gate insulation film, protective film and pixel electrodes thereon.

5. The device as claimed in claim 4, wherein the gate insulation film is formed in a pattern.

6. The device as claimed in claim 4, wherein the protective film is formed in a

pattern.

7. The device as claimed in claim 4, wherein the pixel electrode is formed in a pattern.

8. The device as claimed in claim 4, wherein materials composing the pixel electrodes are indium tin oxide (ITO).

9. The device as claimed in claim 1, wherein the pixel electrode is divided into two regions, each of which includes liquid crystal molecules having different movements from each other.

10. The device as claimed in claim 1, wherein the photo alignment film is divided at least in two regions, each of which includes liquid crystal molecules having different alignment characteristics from each other.

11. The device as claimed in claim 10, wherein at least one region of the photo-alignment film is oriented.

12. The device as claimed in claim 10, wherein none of the regions of the photo-alignment film is oriented.

13. The device as claimed in claim 10, wherein at least one region of the photo-alignment film is photo-aligned.

14. The device as claimed in claim 13, wherein the optical alignment film is formed of a material selected from compounds of PVCN (polyvinylcinnamate), PSCN (polysiloxanecinnamate), or CelCN (cellulosecinnamate) group.

15. The device as claimed in claim 13, wherein the light used for the optical orientation is a light of an UV range.

16. The device as claimed in claim 13, wherein the light is irradiated for at least one time.

17. The device as claimed in claim 1, wherein the liquid crystal is nematic with a positive dielectric anisotropy.

18. The device as claimed in claim 1, wherein the liquid crystal is nematic with a negative dielectric anisotropy.

19. The device as claimed in claim 1, wherein the liquid crystal is vertically aligned to the first or second substrates.

20. The device as claimed in claim 1, wherein at least one of the substrate forms a negative uniaxial film thereon.

21. The device as claimed in claim 1, wherein at least one of the substrate forms a negative biaxial film thereon.

22. The device as claimed in claim 1, wherein the liquid crystal layer has a chiral dopant.

DRAWINGS

FIG. 1a

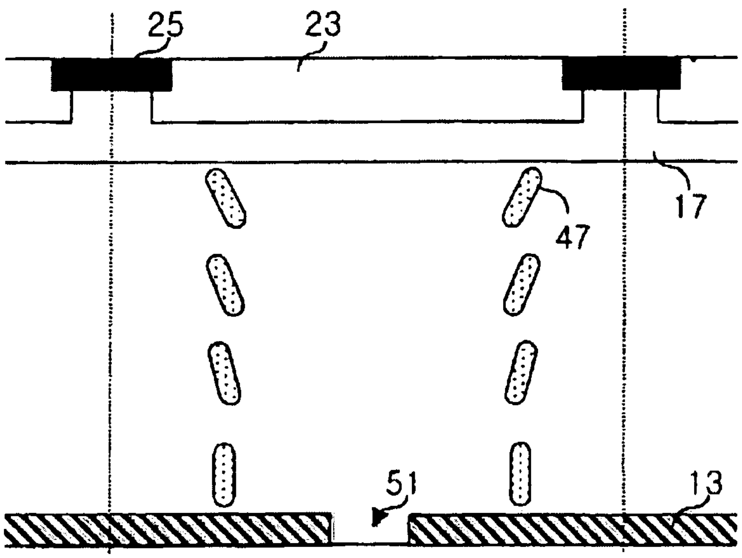


FIG. 1b

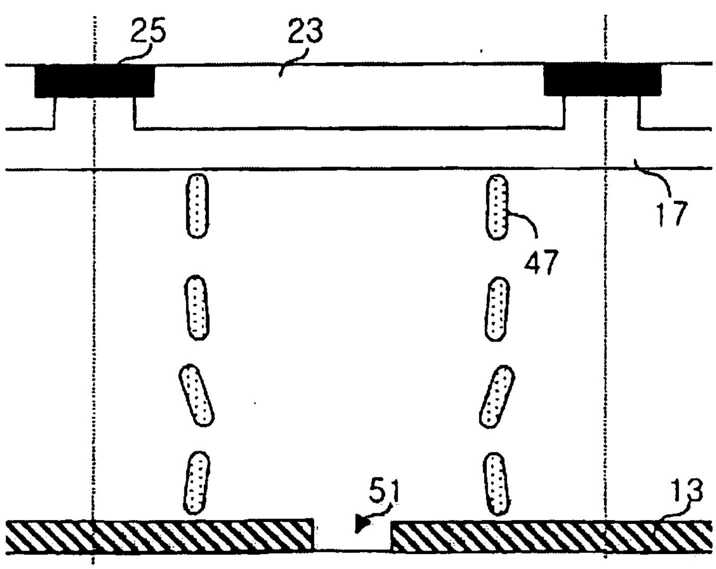


FIG. 2a

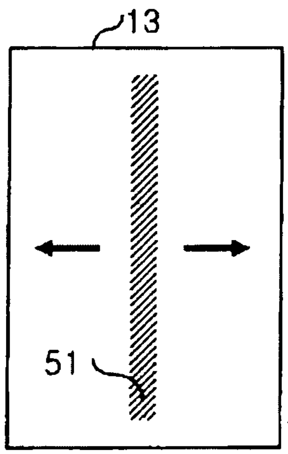


FIG. 2b

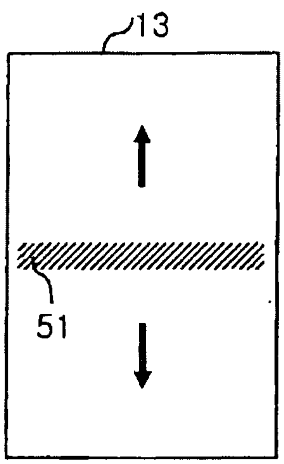


FIG. 2c

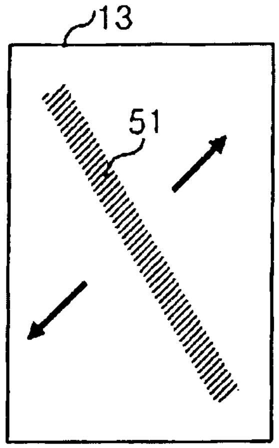


FIG. 2d

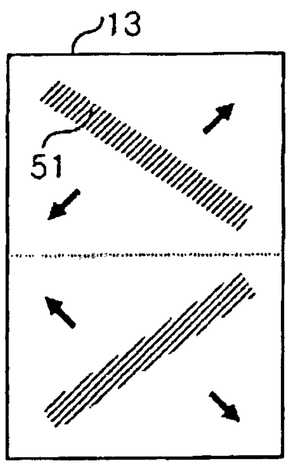


FIG. 2e

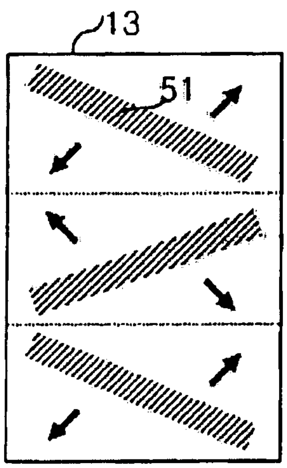


FIG. 3a

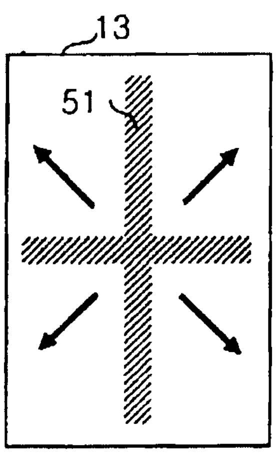


FIG. 3b

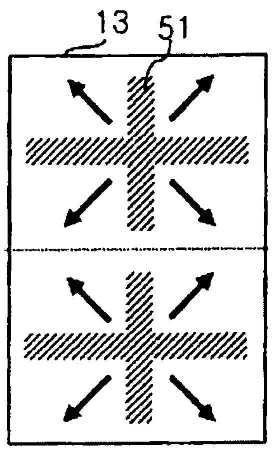


FIG. 3c

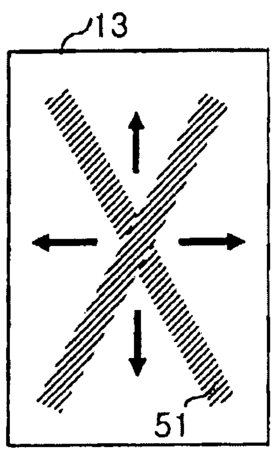


FIG. 3d

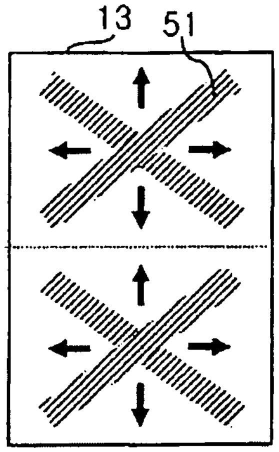


FIG. 4a

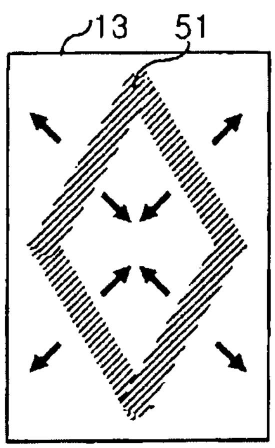


FIG. 4b

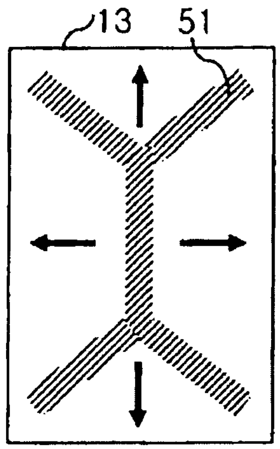


FIG. 4c

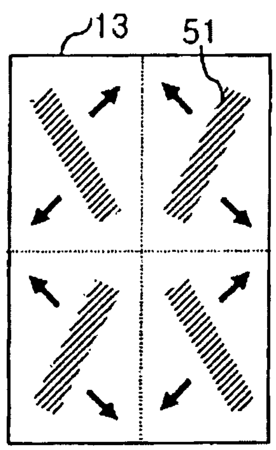


FIG. 4d

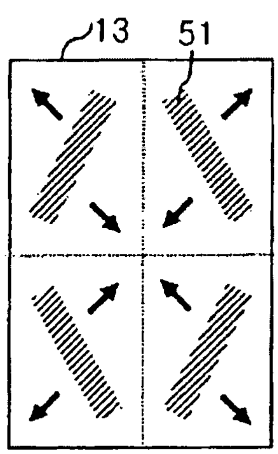


FIG. 5a

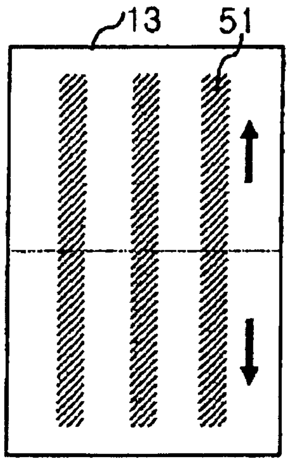


FIG. 5b

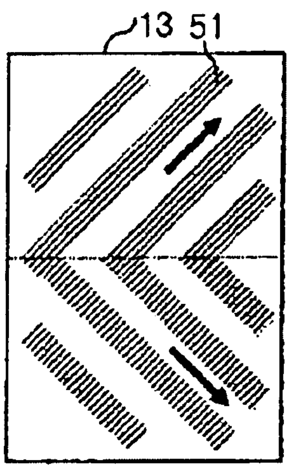


FIG. 6a

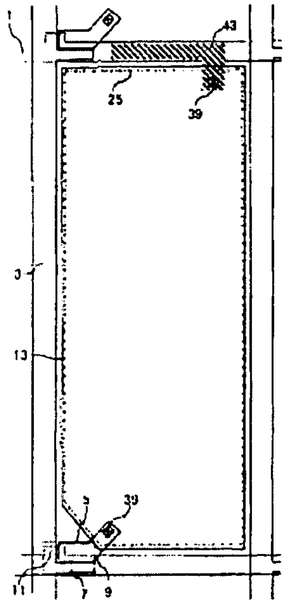


FIG. 7a

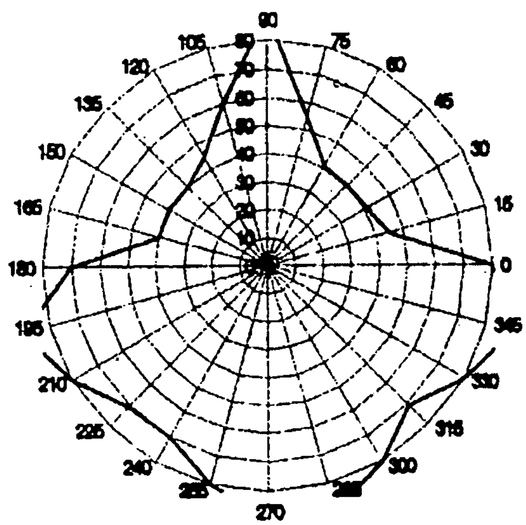
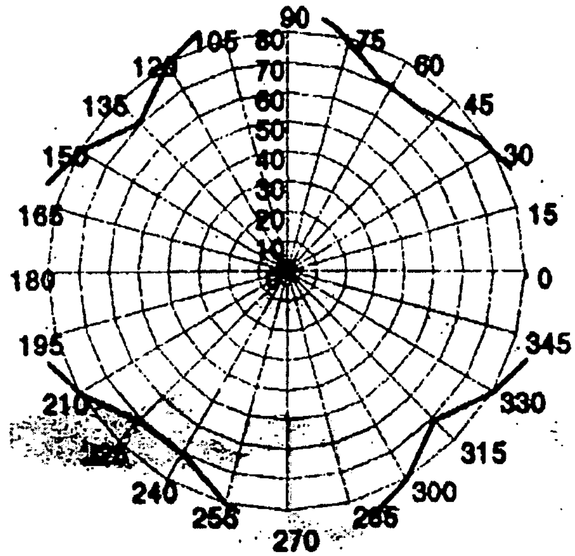


FIG. 7b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